On the Determinants of Chilean Economic Growth

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If looked at since the mid-1980s, Chile's economic performance has been fairly impressive compared not only with the rest of Latin America, but also with most of the countries in the world. From a long-run perspective, however, Chile did not display such an outstanding performance in the 1960s and 1970s. In fact, the growth of Chile's per capita gross domestic product (GDP) was way below the average of East Asia, member countries of the Organization for Economic Cooperation and Development (OECD), and the world economy during those two decades. When compared with the other Latin American countries, the Chilean economy was about average in the 1960s and below average in the 1970s, and it outperformed the rest of Latin American economies in the 1980s and 1990s. This difference is even larger if we consider the period 1984–1998.[1]

Depending on the period under consideration, Chile presents statistically significant differences with respect to other Latin American countries, not only in average per capita GDP growth, but also in its volatility. Informal evidence shows that Chile is influential in the sense that valuable information with respect to the economic performance of the region would be left out without Chile. This is so because Chile

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1. This analysis is based on the latest Penn World Tables; see Summers and Heston (1991) for details.

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displays four characteristics that are not present (at least to the same extent) in other countries. First, Chile's economic performance (in terms of both growth rate and volatility) was similar to the average of the Latin American countries considered until the oil crisis. Between the oil crisis and the debt crisis, Chile displayed atypical vulnerability given the low growth and high volatility exhibited during those crises. Third, the speed of recovery after these crises is unsurpassed by the other countries. Finally, after the debt crises, Chile exhibited not only the highest growth rates of the region, but also a level of volatility that is not statistically different from the average of the region.

A usual candidate for explaining the economic performance of an economy is its investment rate. However, the correlation between per capita GDP growth and the investment rate is at most 0.35. Furthermore, while the investment rate declined steadily from 1960 to 1973, it rose from 1984 to 1998. It could be argued that in the first period, the contribution of capital to growth was very important, while in the second, the recovery from the deep recession of the early 1980s made the growth rate lead the economy to higher investment rates. Anecdotal (statistical) evidence is readily available, given that Granger causality tests suggest that both the level and first difference of per capita GDP preceded the investment rate in the 1984–2000 period, while there is no discernible direction of statistical causation in the 1960–1973 period.

It would be instructive to have formal measures for evaluating the determinants of such a heterogeneous performance during these periods. The issue of particular interest involves identifying which characteristics made it so average until the oil crisis and so sensitive to the two major international crises in the early 1970s and 1980s—and which contributed to the accelerated growth rates and decreased volatility that came after these episodes. Studying Chile's economic performance is interesting not only because of its remarkable differences in terms of growth rates and volatility relative to other countries in the region, but also because it has experienced major swings in terms of its institutional arrangements and economic policies.

This paper provides a qualitative and quantitative evaluation of the main factors behind the Chilean growth process. The rest of the paper is organized as follows: section 1 provides the historical background for the period under analysis. Section 2 conducts a growth accounting exercise that aims to recover total factor productivity (TFP). Section 3 takes the results from section 2 and conducts a multivariate time series analysis that includes several measures of distortions of the Chilean economy and evaluates which of them are important determinants (or consequences) of its economic performance. Section 4 presents a model that incorporates the features found to be relevant in the previous section and quantifies the growth effects of several shocks. Finally, section 5 summarizes the main conclusions and draws policy implications from the Chilean experience.

1. Historical Background

One of the purposes of this paper is to better understand the role of economic policy in the Chilean growth process. This section presents a brief overview of Chile's past economic policies. Lüders (1998) provides a long-term analysis (1820–1995) of the performance of the Chilean economy and compares it with other developing and developed countries. Here, we focus on the last forty years, for which more reliable information is available.

Chile achieved its political independence from Spain in 1810. According to Lüders (1998), the first period of Chilean economic history can be characterized as liberal, with two distinct subperiods 1820–1878 and 1880–1929 (before and after the Pacific War). In the first subperiod, Chile grew above the Latin American average (1.39 percent versus 0.1 percent for the region), while in the second subperiod the growth rate was about average with respect to the same group of countries. The Pacific War had a positive wealth effect for the Chilean economy, but the annexation of nitrate and silver mines may have induced two negative effects: a rapid increase in government expenditures (more rent-seeking activities) and a Dutch disease phenomenon that cut off some traditional activities. From the political standpoint, the second phase of liberal economy was unstable, with a civil war in 1891 and military takeovers in 1924 and 1927–1932.

After the Great Depression, Chile initiated a strategy of import substitution, mainly owing to the negative experience with the price of nitrate. The sudden drop in the price and sales of most of the products that Chile exported induced a significantly negative wealth effect. According to Lüders (1998), Chile was one of the economies that suffered the most during the Great Depression: per capita GDP fell by 47 percent and exports by 79 percent.

The economic ideas that were prevalent at the time also led the economy toward inward-oriented economic policies. An active role was assigned to the government, which implemented industrial policies and created state-owned enterprises. The manufacturing industry was protected with high tariffs, nontariff barriers, and multiple exchange rates. All these movements were implemented between 1940 and 1970, with a weak and unsuccessful attempt to reverse this trend between 1959 and 1961.

In 1970, the newly elected socialist government exacerbated the combination of inward-oriented economic policies and government intervention. From that year until 1973, Chile could accurately be described as a virtually closed economy. Economic policy between 1971 and 1973 was characterized by strong government interventions; price, interest rate and exchange rate controls; high tariff and nontariff barriers to trade and to international capital flows; and a very high inflation rate. The government also expropriated a significant number of private companies in this period.

The military coup of 1973 initiated a movement from high government intervention toward a market-oriented economy. Among the most important changes, the economic policy focused on price liberalizations, an aggressive opening of the economy to trade and international capital flows, a reduction in the size of government, and privatizations. Chile also introduced pioneering reforms to the social security regime, financial markets, and the health care system. One of the most profound reforms was the trade liberalization that eliminated all the nontariff barriers and reduced tariffs to 10 percent across the board (except for automobiles).

All these changes coincided with major international crises (namely, the oil crisis and the debt crisis). The first occurred when the economy was starting the reforms, and the sum of the external shock and the reform affected the performance of GDP. The second crisis stemmed from a mix of a negative external shock (an increase in the international interest rate and a deterioration of the terms of trade) and internal policy mistakes. A fixed exchange rate policy, combined with a very low convergence of domestic to international inflation, induced a large real appreciation of the peso relative to the dollar, creating a large current account deficit. Given the external situation, the foreign sector was not willing to finance the current account deficit; at the same time, the financial system was not consolidated in terms of regulation, supervision, and expertise.[2] The Chilean economy thus experienced a twin crisis (external and financial).

The real exchange rate appreciation of that period constituted a second shock for the tradables sector (the trade reform being the first), which induced several bankruptcies and the need for increased productivity in that sector. The manufacturing sector experienced

2. See Fuentes and Maquieira (2000) and the references therein.

important reallocations of resources coupled with productivity increases.[3] The peso was devaluated in 1982, and tariffs were increased until 1985 (reaching a peak of 35 percent across the board) and then lowered until 1991.

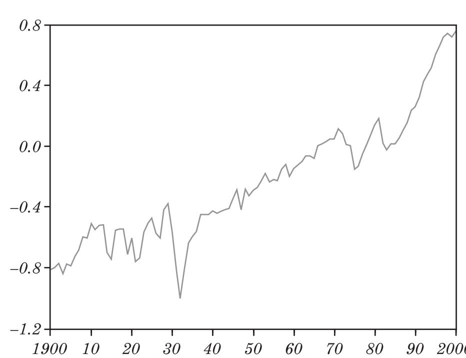
The major economic reforms formulated in the 1980s were left virtually unchanged after the return to democracy in 1990. The newly appointed government reduced tariffs even further, from 15 percent to 11 percent (in 1991), and negotiated free trade agreements with Canada, Colombia, the European Union, Korea, Mercosur, Mexico, and the United States, and Venezuela. These agreements reduced the average tariff paid on imported products. Recently, the tariff structure has been reduced even further (from 11 percent to 8 percent) for countries that are not members of free trade agreements.

This brief overview can be summarized by the evolution of per capita GDP in figure 1. It uses data from Braun and others (2000) and Díaz, Lüders, and Wagner (1999) for the period up to 1995 and official growth rates from the Central Bank of Chile for 1996–2000.

2. Total Factor Productivity Analysis

This section derives several estimates of total factor productivity (TFP) that are later used to uncover factors behind the growth process.

Figure 1. Log of per Capita GDP, 1900–2000



Source: Brown and others (2000), Díaz, Lüderds, and Wagner (1999) and Central Bank of Chile.

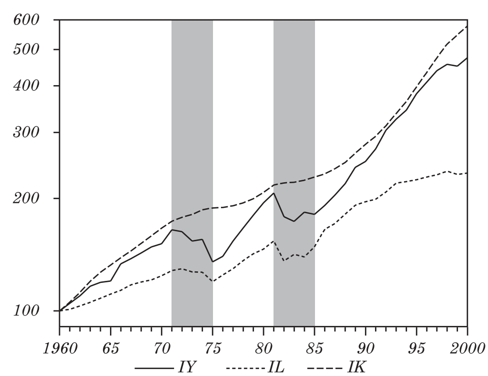
3. See Fuentes (1995); Álvarez and Fuentes (2003). Fuentes (1995) shows that the trade and market reform period (1975–1982) featured substantial increases in the productivity of different manufacturing sectors. A pattern across sectors could not be found, so this feature is consistent with the idea of a mushroom process.

2.1 Data

Given the data availability and its degree of reliability, we conducted this analysis for the period 1960–2000 using National Accounts records. The capital stock was estimated using the perpetual inventory system from 1940.[4] The data on labor corresponds to the number of people occupied each year and is obtained from the National Institute of Statistics (INE).

Figure 2 shows the evolution of GDP, capital stock, and labor for 1960–2000 (expressed as indices). As can be seen, the capital stock grew faster than labor and GDP over the whole sample. Five periods are clearly distinguishable: three periods of rapid growth and two severe recessions.[5] In the first growth period, GDP growth was accompanied by a faster increase in the capital stock and a smooth upward trend in labor. After the recession in the mid-1970s, the economy grew very fast with a relatively slow increase in capital and labor until the beginning of the debt crisis. This profound recession caused with a high increase in the unemployment rate. The economy bounced back starting in the mid-1980s, with a quick recovery in terms of employment and a later rise in the growth rate of capital.

Figure 2. Evolution of GDP, Labor, and Capital, 1960–2000
Index 1960 = 100, with log scaling



Source: Chumacero and Fuentes (2002).

4. Herman Bennett kindly provided this series.

5. The economy experienced a short recession beginning in the last quarter of 1998, with a recovery in 2000. In some parts of our analysis, we assume that the third period of expansion ends in 1998.

2.2 Methodology Used to Estimate TFP Growth

The data discussed in the previous section can be used to estimate TFP growth. One of the key elements for understanding the contribution of productivity is the measurement of production factors and any changes in their quality over time. Here we provide two estimates of TFP growth: one based on the raw data of capital and labor and one that corrects labor with a quality index.

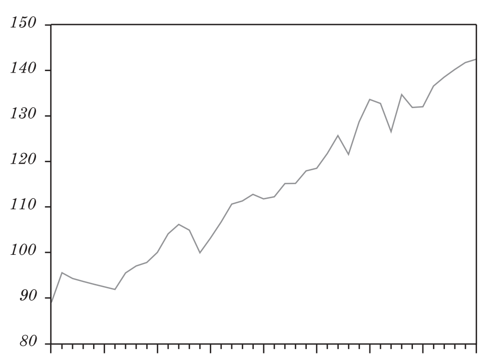
Input quality

An important part of the contribution to the growth process in Latin America has been the increase in the quality of factors (Elías, 1992). One of the usual ways to adjust the raw data is by using a correction that augments labor and capital. For labor, we use the estimate made by Roldós (1997), which considers that there are different types of labor, L_j, with wages w_j, such that the quality correction becomes

$$\sum_{j=1}^{n} \frac{w_j L_j}{wL} \ . \tag{1}$$

Figure 3 shows the evolution of this index over time. We compare it with an estimation of human capital stock found in Braun and others (2000), where the authors express the level of education of the labor force in tertiary education equivalence using the relationship with market wages. The correlation between the two variables is 0.98.

Figure 3. Labor Quality Index



Source: Roldós (1997).

Roldós (1997) also provides a quality index for the capital stock. The construction of the index hinges on relative rental rates of different types of capital. As this information is not available, the author estimates this rate using the market price of investment goods. Figure 4 shows the evolution of this index, which presents two disturbing features. The quality of capital declined throughout the 1960s, and the quality of capital goods in 1995 was at about the same level as in 1960. The former trend, in particular, is difficult to explain. We therefore chose not to use this variable in the study.

Greenwood and Jovanovic (2000) provide another view of improvement in the quality of the capital stock. They associate quality with the evolution of the relative price of investment in terms of consumption; when this relative price decreases, the quality of capital goods rises. There are at least two problems with this interpretation. First, at the aggregate level, there are no permanent decreases in the relative price of equipment (even though we separated equipment from structure). In the case of computers, for example, we can expect a continuous decreases in their relative prices, but this may not be the case for other types of equipment. When a higher quality of equipment appears on the market, its price might be higher than that of earlier models, since the firm may exploit monopoly rents to pay for research and development (R&D) costs (quality ladder models, as in Grossman and Helpman, 1991); the price of equipment may thus actually rise. The second reason is that in linear technology models of endogenous growth, a decrease in the price of an investment good will increase capital accumulation and, ultimately, the growth rate. This would be the case when an economy opens to trade and starts importing capital goods at a lower price (Jones and Manuelli, 1990).

Figure 5 shows the evolution of the prices of equipment goods and investment goods relative to consumption goods. Although they seem to follow the evolution of the real exchange rate (rather than being good estimates of the quality of capital), we assess the impact of these relative prices on TFP in the next section.

TFP growth measures and capital share estimates

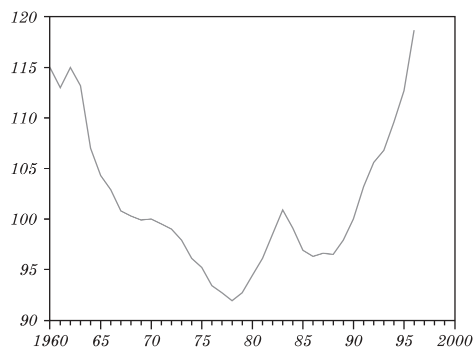
Given the considerations discussed above, we analyze two different formulations for TFP. The first does not consider any correction for changes in factor quality, while the second includes a correction for human capital (TFPH). Thus the equations for TFP growth are

$$\hat{\text{TFP}} = \hat{Y} - \alpha\hat{K} - (1-\alpha)\,\hat{L} \text{ and} \tag{2}$$

$$\hat{\text{TFPH}} = \hat{Y} - \alpha\hat{K} - (1-\alpha)\,\hat{L} - (1-\alpha)\hat{H}\ , \tag{3}$$

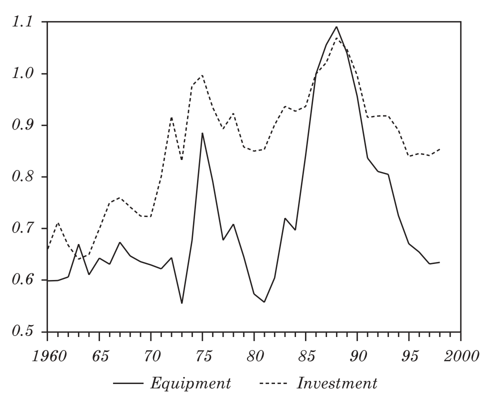
where H represents the index of labor quality and $\hat{w}$ denotes the growth rate of variable w. With either measurement, TFP growth includes both improvements in the quality of capital over time and the technological shock.

Figure 4. Capital Stock Quality Index



Source: Roldós (1997).

Figure 5. Price of Equipment and Investment Goods Relative to Consumption Goods



Source: Chumacero and Fuentes (2002).

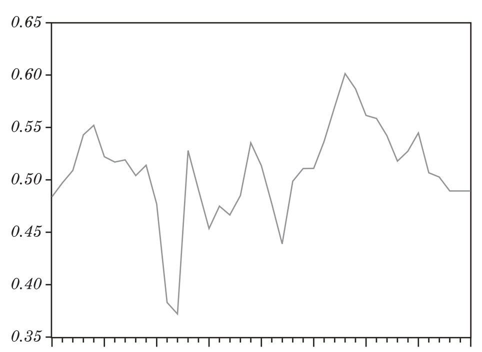
The key parameters necessary for estimating TFP are the factor-output elasticities. From the viewpoint of pure growth accounting, the estimates of the elasticities are given by the capital and labor shares from the National Accounts. These shares vary from year to year, so we made the calculations using the average capital and labor shares for two years and the average shares for the entire period (α = 0.50733). There is not much difference between these two choices. An alternative estimation used in this exercise is the capital share conventionally used in the growth literature (0.333). The correlations of the growth rates of estimates of TFP under different assumptions for a is never smaller than 0.98.

Despite the similarities of the TFP measures using a variable or a constant α, there is always a reasonable doubt as to which model best describes the data. For instance, a CES function may do a better job than a Cobb-Douglas production function. Figure 6 provides informal evidence suggesting that a constant capital-output elasticity is not a bad approximation. In particular, the value in 2000 is about the same as in 1960 and close to the average. A regression on a constant, however, shows that the mean is not stable over time. This fact could be reconciled with changes in the input-output matrix from the National Accounts (1977 and 1986).

2.3 Estimation of TFP Growth

Table 1 shows the TFP growth rate for the entire period (1960–2000) and for two subperiods. The first subperiod corresponds to the inward-oriented phase, while the second starts with the trade reform.

Figure 6. Capital Share



Source: Chumacero and Fuentes (2002).

Table 1. Growth Accounting for Periods of Economic Orientation and Rapid Growth[a]

Period	*GDP growth*	*TFP (α = 0.507)*	*TFP (α = 0.333)*	*TFPH (α = 0.507)*	*TFPH (α = 0.333)*
1960–2000	3.97	0.67	1.07	0.06	0.24
1960–1974	3.19	0.06	0.55	–0.37	–0.04
1975–2000	4.40	1.00	1.36	0.29	0.39
Rapid growth					
1960–1971	4.65	0.91	1.41	0.18	0.42
1975–1981	7.32	3.97	3.65	3.27	2.69
1985–1998	7.36	2.23	2.72	1.54	1.77

a. TFPH denotes the inclusion of human capital in total factor productivity.
Source: Authors' calculations.

The table indicates a difference of more than one percentage point between periods, mostly accounted for by differences in TFP growth. This feature signals that the elimination of distortions may have significantly increased the economy's efficiency.

The lower panel of the table presents the TFP growth rate for the shorter periods of rapid growth in the Chilean economy. Two of these correspond to the trade liberalization of the 1970s and the tariff reduction of the late 1980s and early 1990s (after the debt crisis). The performance of TFP growth is rather poor over the whole sample (growing at most at 1 percent), while GDP grew at 4 percent per year, on average.

As figure 2 made clear, we distinguish three episodes of growth. It is instructive to evaluate the differences in growth rates of TFP among these periods. The GDP growth rate in the 1975–1981 and 1985–1998 episodes might be influenced by the recovery from the two deep recessions of the 1970s and 1980s, but both cases feature significant increases in TFP that are not apparent in the 1960s. Average TFP growth reached its highest value in the trade reform period (the late 1970s), which is characterized by important factor reallocations, firm bankruptcies, and the creation of new firms. In the longest period of continuous growth (1985–1998), TFP growth was somewhere between 1.5 and 2.7 percent—a more modest rate than in the 1975–1981 episode.

How important was TFP in accounting for GDP growth? This is important because both TFP growth rates and GDP growth rates were higher in the 1975–1981 and 1985–1998 episodes. Table 2 shows the contribution of factor accumulation (including human capital) and TFP to growth. As expected, the contribution of TFP for the entire period was very small after including human capital. The most important

Table 2. Growth Accounting for Periods of Rapid Growth[a]

Parameter value and period	*Labor*	*Human capital*	*Capital*	*TFPH*
$\alpha = 0.5073$				
1960–2000	0.27	0.15	0.57	0.01
1960–1971	0.25	0.15	0.56	0.04
1975–1981	0.29	0.09	0.17	0.45
1985–1998	0.25	0.09	0.45	0.21
$\alpha = 0.3333$				
1960–2000	0.36	0.2	0.38	0.06
1960–1971	0.33	0.21	0.37	0.09
1975–1981	0.39	0.13	0.11	0.37
1985–1998	0.33	0.12	0.3	0.25

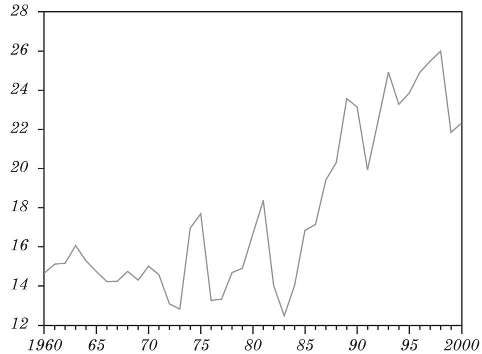
a. TFPH denotes the inclusion of human capital in total factor productivity.
Source: Authors' calculations.

contribution to growth was physical capital, which accounts for 57 percent of total GDP growth.

The growth rate of GDP over the 1960s is characterized by capital accumulation, human capital accumulation, and the lack of total factor productivity growth. As expected, the TFP growth rate played a key role in accounting for growth after 1975, but capital accumulation results in an important difference between the 1975–1981 and 1985–1998 periods. Furthermore, while capital accumulation accounts for the successful period after the debt crisis, it was not as fast as in the 1960s. As the growth literature predicts, trade liberalization and the movement of the Chilean economy toward a free market economy that began in the mid-1970s brought important total factor productivity growth.

Our TFP growth estimates are also capturing improvements in the quality of the capital stock and other factors (such as changes in relative prices, resources allocations, and so forth), as mentioned above. From this viewpoint, and following Greenwood and Jovanovic (2000), the reduction in trade restrictions should have increased the average quality of the capital stock and thus led to a higher TFP growth. This feature is even more important if we take into consideration that the contribution of capital accumulation was very high in the first period of growth (1960–1971), while the other two periods featured a lower rate of capital accumulation accompanied by higher growth rates in the Chilean economy. This is in line with economic theory that suggests that opening the economy to trade and the elimination of distortions increase the average quality of capital and improve the allocation of capital toward sectors with higher marginal productivity. The evolution of the investment rate presented in

Figure 7. Investment Rate, 1960–2000
Percent of GDP



Source: Chumacero and Fuentes (2002).

figure 7 (using current prices) highlights the efforts from increasing the investment rate in the last period.

Trade reform and the reduction of government intervention in the economy are key features to consider when evaluating the performance of the economy in the 1980s and 1990s. As mentioned in section 1, however, several other reforms could also account for the increased marginal productivity of capital and increased growth, including the banking and capital market reforms combined with the new bankruptcy law.[6] In a recent paper, Bergoeing and others (2002) highlight these reforms as key for explaining the fast recovery of the Chilean economy after the debt crisis.

Another important difference between the rapid growth of the 1960s and that of the other two episodes lies in the contribution of human capital. Two caveats can be made with respect to this observation. First, educational attainment has increased continuously over time, such that "enough" human capital may already have been accumulated by the 1970s, making the marginal contribution of human capital modest. Second, the human capital series was measured using relative wages, but the changes in these wages may be due to factors other than human capital accumulation. At any rate, studies show that even when measured differently, the contribution of human capital is not that different from what we find here (Schmidt-Hebbel, 1998).

6. Fuentes and Maquieira (2000) provide an explanation of how these laws affected the recovery of the banking system after the deep banking crisis in the early 1980s.

3. Multivariate Analysis

The above section constructed variables for better understanding the growth experience of the Chilean economy, in particular outlining the evolution of total factor productivity and identifying its importance at different stages of the recent Chilean growth history. This series can be used to evaluate the main determinants of the variables and thus the determinants of growth. Here, we conduct several econometric exercises that provide quantitative and qualitative guidelines with respect to the type of theoretical model that can be used to understand the growth dynamics of the Chilean economy.

3.1 Factors behind TFP

In section 2 we obtained several estimates for TFP. We now consider a set of variables that may be associated with them, including time series for terms of trade, variables that capture the evolution of distortionary policies (such as tariffs and fiscal expenditure over GDP), and the prices of equipment and investment goods relative to consumption goods.[7]

Our econometric formulations begin with over-parameterized models. Careful reductions and reparameterizations then generate models for TFP series (in logs) that can be expressed as

$$f_t = a_0 + a_1 t + a_2 f_{t-1} + a_3 f_{t-2} + a_4 p_t + a_5 p_{t-2} + a_6 T_t + a_7 T_{t-1} + a_8 g_{t-1} + e_t \ , \tag{4}$$

where a_i are coefficients to be determined, f is the log of each TFP series, p is the log of the price of equipment goods relative to consumption goods, T is the log of the terms of trade, and g is the ratio of fiscal expenditures to GDP.

Table 3 shows the results of the estimations (for statistically significant variables only). Given the close association between the TFP measures, the characteristics and even the coefficients associated with

7. The last variables take into account the derivations of Greenwood and Jovanovic (2000). In the spirit of that paper, movements of relative prices would be related to the quality of the capital stock and not directly to TFP per se. Consequently, if either of these relative prices appears as significant, we could subtract their participation from the TFP series, Nevertheless, a case could be made for associating the evolution of these relative prices to modifications in distortionary policies, thereby making these prices a combination of the effects of increases in the quality of capital and reduced distortions.

each variable are remarkably similar: in all cases, reductions in the price of equipment goods relative to consumption goods, improvements in the terms of trade, and reductions in the participation of government expenditures to GDP are positively associated with our measures of TFP. We also find that TFP can be characterized as trend stationary (consistent with our results from section 2). Thus, every transitory shock on the variables included in the regressions would have only transitory effects on the levels of our TFP estimates.

This does not mean that policies are not important, but rather that transitory policy shocks do not have permanent effects, although they have effects on the level of the series. As expected, a_4 and a_5, when significant, are negative; if these variables measure the quality of capital, a reduction in the price of equipment relative to consumption goods signals an improvement in the quality of capital stock.

Table 3. Results of TFP Regressions[a]

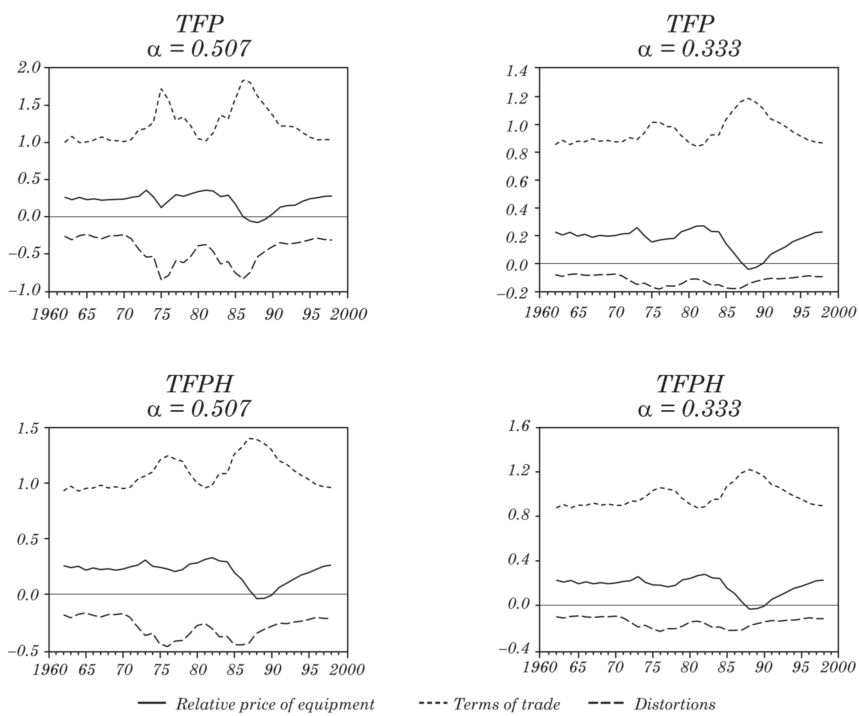
Parameter	*TFP* (α = 0.507)	*TFP* (α = 0.333)	*TFPH* (α = 0.507)	*TFPH* (α = 0.333)
a_1	0.008	0.010	0.005	0.006
	(0.001)	(0.004)	(0.001)	(0.001)
a_2	0.349			
	(0.135)			
a_3	–0.269	–0.405	–0.501	–0.377
	(0.116)	(0.182)	(0.155)	(0.156)
a_4	–0.220	–0.303	–0.259	–0.283
	(0.038)	(0.033)	(0.032)	(0.035)
a_5		–0.141	–0.197	–0.210
		(0.068)	(0.061)	(0.065)
a_6	0.083	0.082	0.164	0.116
	(0.026)	(0.038)	(0.033)	(0.039)
a_7		0.083		0.072
		(0.030)		(0.033)
a_8	–0.571	–0.410	–0.852	–0.576
	(0.119)	(0.139)	(0.113)	(0.114)
Summary statistic[b]				
Adjusted R^2	0.940	0.963	0.913	0.915
Durbin-Watson statistic	2.199	1.895	2.015	1.858
Q	0.115	0.199	0.241	0.793
Q^2	0.741	0.109	0.159	0.467
Jarque-Bera normality test (p value)	0.629	0.572	0.852	0.365
Ramsey test (p value)	0.174	0.286	0.081	0.167

a. Standard errors are in parenthesis.
b. Q equals the minimum p value of the Ljung-Box test for white noise on the residuals; Q^2 is the minimum p value of the Ljung-Box test for white noise on the squared residuals.
Source: Authors' calculations.

In this regard, this variable captures the exclusion of the adjustment for the quality of the capital stock in our growth accounting exercise, as well as possible reductions in distortions. Also of interest is the positive effect of the terms of trade on TFP and the negative and statistically significant effect of the size of the government as a fraction of GDP. It may be argued that this last variable can not be considered exogenous given that it may have been used to conduct countercyclical policies. We find evidence that g is weakly exogenous to the parameter of interest (in the sense of Hendry, 1995), thus conditioning our estimates of TFP on g is a valid econometric practice.

Figure 8 presents the contribution of each variable to TFP after we have removed the trend and persistence component. We find that the evolution of the terms of trade accounts for almost all of the variation in TFP (excluding the trend component) and that the negative effect of our measure of distortions more than offsets the improvements in the quality of the capital stock.

Figure 8. Effect on TFP



Source: Authors' calculations.

Given that all of our TFP estimates are robustly associated with these three variables, we estimate a simple model for the level of (log) GDP that associates it with them. Next, we use the impulse response functions of the innovations of these variables on GDP as a metric with which to compare the theoretical model developed in the next section. This simple econometric formulation provides well-behaved residuals and successfully passes all of our specification tests. It is given by

$$y_t = b_0 + b_1 t + b_2 y_{t-1} + b_3 p_t + b_4 T_t + b_5 g_t + e_t \ , \tag{5}$$

where b_i are coefficients to be determined, y is the log of GDP, and all the other variables are as defined in equation (4).

We find that the price of equipment relative to consumption goods and our proxy for distortions are negatively associated with GDP, while improvements in the terms of trade have positive effects on GDP (see table 4). Consistent with our previous findings, we model y as a trend stationary series; all the regressors included thus have only transitory effects over the scale variable. Furthermore, weak exogeneity conditions are satisfied by p, T, and g.

Next, we estimate laws of motion for p, T, and g as univariate time series models. These simple specifications provide good statistical approximations for the processes of each variable and are able to account for most of their dynamic characteristics.[8]

Table 4. Results of GDP Regressions

Parameter	*y*	*Standard error*
b_1	0.017	0.005
b_2	0.615	0.106
b_3	–0.163	0.064
b_4	0.107	0.051
b_5	–0.634	0.174
Summary statistic[a]		
Adjusted R^2	0.99	
Durbin-Watson statistic	1.817	
Q	0.262	
Q^2	0.15	
Jarque-Bera normality test (p value)	0.099	
Ramsey test (p value)	0.257	

a. Q equals the minimum p value of the Ljung-Box test for white noise on the residuals; Q^2 is the minimum p value of the Ljung-Box test for white noise on the squared residuals.

8. VAR models were also considered for obtaining the multivariate representation of these variables. Our results do not change significantly if a VAR(1) representation is considered instead of simple univariate representations.

4. Back to Fundamentals

Chumacero and Fuentes (2002) calibrate a dynamic stochastic general equilibrium model that explicitly introduces the theoretical counterparts of *p*, *T*, and *g*. This section summarizes the model and presents the results of that earlier paper.

The economy is inhabited by a representative agent who maximizes the expected value of lifetime utility as given by

$$E_0 \sum_{t=0}^{\infty} \beta^t u(c_t, l_t) \text{ , with}$$

$$u(c_t, l_t) = \theta \ln c_t + (1-\theta)\ln(1-l_t) , \tag{6}$$

where $0 < \theta < 1$ and where c_t and l_t represent consumption of an importable good and labor in period *t*. Two goods are produced in this economy; good 1 is not consumed domestically, while good 2 (the importable good) is produced domestically and can also be imported. We assume that the output of the exportable good (y_1) is constant and can be sold abroad at a price (expressed in terms of the importable good) of T_t. Thus, T_t represents the terms of trade in our economy. The production technology for the importable good is described by

$$y_{2,t} = e^{z_t} k_t^{\alpha} l_t^{1-\alpha} , \tag{7}$$

where α is the compensation for capital as a share of output of sector 2. As before, production in this sector is also affected by a stationary productivity shock, z_t, that follows an AR(1) process (that is, autoregressive of order one).

The resource constraint of the economy is given by

$$c_t + i_t + g_t = T_t y_1 + y_{2,t} , \tag{8}$$

where investment (i) and government expenditures (g) are expressed in units of consumption of importables.

The capital accumulation equation is

$$k_{t+1} = (1-\delta) k_t + i_t q_t , \tag{9}$$

where *q* denotes the current state of technology for producing investment goods and represents investment specific technological change (following Greenwood, Hercowitz, and Krusell, 2000). Given that *i* is expressed in consumption units, *q* determines the amount of investment in efficiency units that can be purchased for one unit of consumption. Thus, a higher realization of q directly affects the stock of new capital that will be active in production in the next period. We assume that ln(q) follows an AR(1) process.

As discussed in Greenwood, Hercowitz, and Krusell (2000), the relative price for an efficiency unit of newly produced capital is the inverse of q, using consumption of the importable good as numéraire. This $1/q$ is our theoretical counterpart to p of section 3.

Finally, the government of this economy levies taxes on labor and capital income at the rates τ_l and τ_k. Part of the revenue raised by the government in each period is rebated back to agents in the form of lump-sum transfer payments (F), and part of it is lost in government expenditures that do not provide services to the representative agent. The government's budget constraint is then

$$F_t + g_t = \tau_k r_t k_t + \tau_l w_t l_t \ , \qquad (10)$$

where r and w represent the market returns for the services provided by capital and labor. Finally, we also assume that ln(g) follows an AR(1) process.

The base configuration of the parameters is presented in table 5. Note that θ is set to reproduce a steady-state participation rate of l equal to 0.35 and the depreciation rate is calibrated to match the average investment rate in the steady state. The persistence and volatility of p, T, and g are made consistent with AR(1) estimates obtained with observed data on the price of equipment relative to investment, the terms of trade, and government expenditures (in this case we include a time trend that is absent in the model). Finally, the persistence and volatility of the technology shocks are estimated by simulation to match as closely as possible the results of table 5.

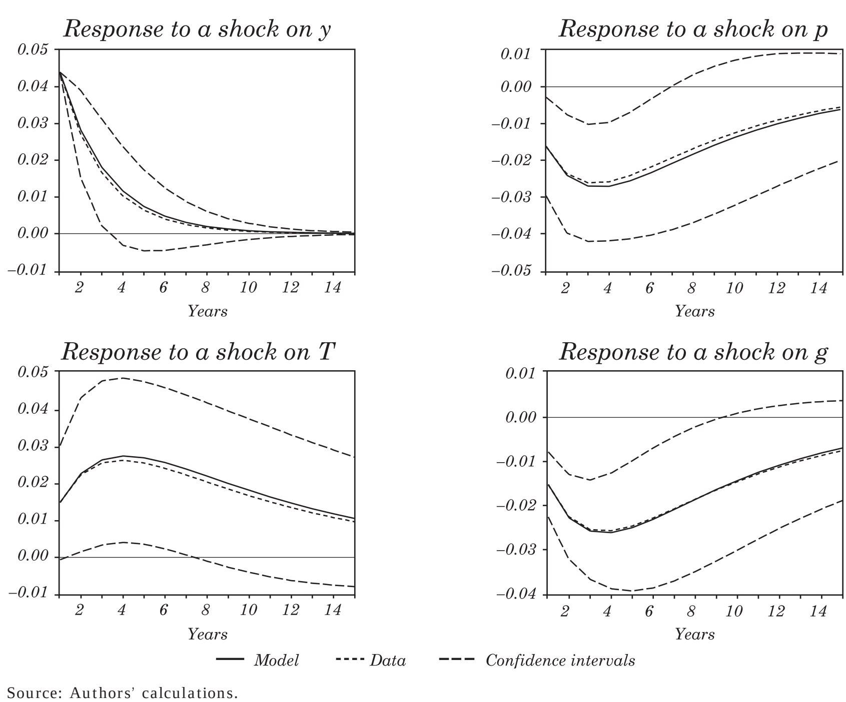
Table 5. Parameters

Block	*Parameters*	
Preferences	β = 0.980	θ = 0.430
Technology	α = 0.333	δ = 0.060
Taxes	τ_k = 0.25	τ_l = 0.25
Shocks	ρ_z = 0.730	σ_z = 0.040
	ρ_p = 0.844	σ_p = 0.100
	ρ_T = 0.892	σ_T = 0.140
	ρ_g = 0.895	σ_g = 0.024

Once we have set the values of the parameters, we solve the model, simulate artificial realizations from it, and compare the impulse response functions of several shocks. According to our specification, the policy functions of the control variables cannot be obtained analytically, and we have to resort to numerical methods. We use a second-order approximation to the policy function using perturbation methods. This method has the advantage of explicitly incorporating the volatility of shocks in the decision rule, and it is superior to traditional linear-quadratic approximations (see Schmitt-Grohé and Uribe, 2004).

Figure 9 presents the results of comparing the impulse response functions of shocks on the innovations of the equation that describes y in equation (5) and innovations on p, T, and g from their univariate representations. Along with the impulse response functions and the 95 percent confidence intervals obtained from the data, the figure shows the impulse response function obtained from a long simulation of the model. Our results indicate an almost perfect match between the impulse response functions of the model and the data.

Figure 9. Impulse Response Functions: Model and Reality



Source: Authors' calculations.

The results of the impulse response functions point to a positive shock of 10 percent on the price of equipment relative to investment has a negative (but transitory) effect on GDP of almost 3 percent after three years. On the other hand, a positive shock of 14 percent to the terms of trade has a positive effect on GDP that, on average, reaches its peak of almost 3 percent after three years. Finally, a transitory increase of 2.4 percent in the share of government expenditures over GDP has an exactly offsetting effect on GDP (decline of 2.4 percent) after three years.

Thus, our theoretical model not only captures the first moments of key variables of the Chilean economy, but matches almost perfectly the impulse response functions of the dynamic characterization of GDP. This shows that a model incorporating the price of equipment relative to consumption goods, the terms of trade, and distortions (measured as the share of government expenditures in GDP) predicts the same qualitative and quantitative responses of GDP to transitory shocks.

5. Concluding Remarks

The objective of this study was to better understand the factors behind the growth dynamics in Chile. Chile has experienced deeper recessions than most Latin American countries when faced with an external shock (the Great Depression, the oil shock and external debt), but at the same time it has experienced an impressive and stable growth in the past sixteen years.

Looking at the evolution of GDP over the last four decades, we distinguish three periods of continuous growth: 1960–1971, 1975–1981, and 1985–1998. The first period corresponds to a moderately inward-oriented economy; the second is the period of major trade liberalization and market reforms; and the third represents the period in which many of the reforms from the previous decade were consolidated. Two other characteristics worth highlighting are that the periods of growth had different lengths and different growth rates. While the economy grew at less than 5 percent in the 1960s, the growth rate was above 7 percent in the other two periods.

The question of why the recent growth period is so different from that of the 1960s can be addressed by analyzing the behavior of TFP growth. No reliable measures of the quality of capital stock are available, however, so we used series for human capital along with different capital shares to estimate TFP.[9] Our results suggest that physical capital and human capital accumulation were the most important factors behind growth in the 1960s, while TFP played a major role in the other two periods, especially in 1975–1981. In the 1985-1998 period, both capital accumulation and TFP growth account for growth.

Following the literature on growth and distortions, we examined whether distortions have anything to do with the evolution of the level of TFP after controlling for good luck (positive external shocks measured by the terms of trade), exogenous technological progress, and the quality of capital (proxied by the price of equipment relative to consumption, following Greenwood and Jovanovic, 2000). We found that exogenous technological shocks, the terms of trade, the price of equipment relative to consumption, and distortions account for a good deal of the evolution of TFP. Of these, the terms of trade and distortions have the largest impact on the level of TFP.

The main policy implication that can be drawn from the Chilean experience—for other countries as well as for Chile itself—is that good policies matter. The most robust measure of distortions that we found in this document is captured by the share of fiscal expenditures on GDP. This variable not only offsets the positive effects of improvements in the quality of capital goods, but also has detrimental effects on the level and volatility of the Solow residuals. External shocks are important, of course, but among the variables that can be controlled by the authority, distortionary policy contributes most to explaining several of the episodes of mediocre growth in Chile.

These findings provide guidelines with respect to the features that a theoretical model should have in order to account for the dynamics of our TFP estimates and the dynamics of GDP itself. Building on these observations, we calibrate, solve, and simulate a small open economy model that incorporates terms-of-trade shocks, the price of investment relative to consumption goods, and distortionary taxes that help finance government expenditure. This model is able to replicate (almost exactly) the impulse response functions of several shocks on the trajectory of GDP. We find that a 1 percent transitory increase in the share of government expenditures in GDP has a detrimental effect on GDP of the same order of magnitude (a decrease of 1 percent in GDP) by the third year. Transitory increases of 1 percent in the terms of trade or decreases in the relative price of investment

9. We used two values extensively: 0.507 (from pure growth accounting) and 0.333 (from the growth literature).

goods have positive and temporary effects on GDP, which are not as important as the quantitative effects of increased distortions.

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